**How this investigation fits within the “Concept and Lesson Map”:**

**Overview for Investigation 3**

After looking at the rotational motion of spinners, students will now build on these understandings and investigate the motion of rolling objects.

**Overarching question(s) for this whole investigation:**

* How can rolling objects be changed and what effect do changes have on the motion of the object?
* How can a rolling object maintain its motion?

**Attending to “How People Learn”**

**How People Learn Key Finding #1: Preconceptions**

**Eliciting Students Ideas:**

There is a nice formative assessment that can be used as a way to pull out student ideas with this lesson. It is found in Uncovering Student Ideas in Science Vol. 3. The title is Rolling Marbles (see attached).

**Common Student Preconceptions:**

* Students are going to come in with a gut “feeling” for how and why moving objects behave the way they do. These are very well engrained from their prior experiences and sense of how the world works. Because of this, it can be difficult for students to give up these intuitive naïve explanations come to a more scientific (and more abstract/less intuitive to them) understanding. It is important to allow them to plenty of time to investigate these phenomena and continue to build on and challenge their ideas. At this point they are not expected to have a full Newtonian/scientific understanding of forces and motion, but these experience and observations will form a foundation for developing these ideas at a later time.
* In Part 3 “rolling spheres,” the students often think that having the entire track system at a higher elevation will cause the marble to come out of the track faster—not realizing that they need to change the track itself to influence the sphere’s behavior. Allow them plenty of time to try, but be sure to check in with them and find their evidence that the change in elevation caused an increase in speed. (often they will imagine that it is faster, because they predicted it would be so.)

**How People Learn Key Finding #2: Facts/Concepts/Knowledge**

**WA State Content Standards “Science Domains” (EALR 4):**

* 2-3 PS1A Motion can be described as a change in position over a period of time.
* 2-3 PS1B There is always a force involved when something starts moving or changes its speed or direction of motion.

**WA State Content Standards “Science Domains” (EALRs 1-3):**

* 2-3 SYSA A system is a group of interacting parts that form a whole.
* 2-3 INQA Scientific investigations are designed to gain knowledge about the natural world.
* 2-3 INQC Inferences are based on observations.
* 2-3 INQE Models are useful for understanding systems that are too big, too small, or too dangerous to study directly.
* 2-3 INQF Scientists develop explanations, using observations (evidence) and what they already know about the world. Explanations should be based on evidence from investigations.

**Benchmarks for Science Literacy:**

* 1a When a science investigation is done the way it was done before, we expect to get a very similar result.
* 1a Science investigations generally work the same way in different places
* 1b People can often learn about things around them by just observing those things carefully, but sometimes they can learn more by doing something to the things and noting what happens.
* 1b Describing things as accurately as possible is important in science because it enables people to compare their observations with those of others.
* 1b When people give different descriptions of the same thing, it is usually a good idea to make some fresh observations instead of just arguing about who is right.
* 1c Everybody can do science and invent things and ideas
* **1c In doing science, it is often helpful to work with a team and to share findings with others. All team members should reach their own individual conclusions, however, about what the findings mean.**
* **4f Things move in many different ways, such as straight, zigzag, round and round, back and forth, and fast and slow.**
* **4f The way to change how something is moving is to give it a push or a pull.**
* **4g Things near the earth fall to the ground unless something holds them up.**
* 6d People can learn from each other by telling and listening, showing and watching, and imitating what others do.
* 9d Some things are more likely to happen than others. Some events can be predicted well and some cannot. Sometimes people aren’t sure what will happen because they don’t know everything that might be having an effect.
* 9e People are more likely to believe your ideas if you can give good reasons for them.
* 12a Raise questions about the world around them and be willing to seek answers to some of them by making careful observations and trying things out.
* 12d Draw pictures that correctly portray at least some features of the thing being described.
* 12e Ask “How do you know?” in appropriate situations and attempt reasonable answers when others ask them the same question.

**Key understandings for the teacher:**

Things move because the forces on them are not balanced. For a wheel, if the center of gravity is not over the base, the wheel will roll. This can be caused by a “push,” a change in weight of the wheel, or by changing the angle of the surface the wheel is on. Other variables can also be changed when experimenting with wheel systems. Moving the axle or changing the size of the wheel will result in different types of motion. Larger wheels will travel further with each rotation and two different sized wheels will cause a system to curve or turn toward the smaller (travelling less distance per revolution) wheel. This leads to the idea that “things move in many different ways...”

A sphere is like a special kind of wheel that can roll in any direction on its own and does not require being part of wheel/axle system. Like the wheel system a marble will remain at rest unless a force acts on it. Once moving the marble will always travel in a straight line unless another force acts on it. Like a sphere, when a marble is placed on a slope, the center of gravity is shifted and this causes the marble to move from the higher location to the lower location. Once a moving marble has momentum it can roll uphill for periods of time, but it will never be able to end up higher than it started. The marble can also be made to turn as the outer edges of a curved section of track can exert a force (push) on the marble to cause a change in direction.

As the students work with wheel/axle systems, cups, and spheres, you will want to continue to point out the similarities between these “rollers,” This will help students make connections between these objects and promote transference of these general ideas to other things that roll. They will be able to build on this knowledge of motion as they continue to study physics.

**How People Learn Key Finding #3: Metacognition**

**Metacognition: How did my thinking change? What caused the change? How did I come to believe this?**

At the end of Part 3, Students could revisit and try out their ideas from the “Rolling Marbles” assessment probe. They could even take the same assessment again as a post assessment after learning about rolling objects. They could then compare their current ideas to the pre-assessment and reflect on the changes in their thinking and which activities caused those changes.

**Suggested Assessments for Student Understanding:**

FOSS Student sheet No. 10 will assess whether students understand the idea that a marble will only move from high to low.

The fossweb game “Roller Coasters” has the students build a track that could take the marble to the other edge of the screen. If students printed a screen shot of their coaster prior to testing it, their coaster could be used as an assessment.

**Additional Information**

Materials and Student Management

* Keeping the marbles in the cups when they are not being used is very important.
* Students will have to work in larger groups to complete some of the tasks in Part 3
* FOSSWEB has an audio versions of the Big Book (<http://www.fossweb.com/modulesK-2/BalanceandMotion/index.html>)
* Bowling is a good cross curricular connection to PE (If you have the large wooden spools for kids to walk on, those are excellent “rollers” as well)
* In Part 2 “rolling cups” in order to “park the car” you need an un-carpeted surface where there is less friction to slow down the circles. Also, you need quite a bit of room for the cups to make a complete circle.

Timing Considerations

It is important to allow your students as much time as possible to explore their ideas and make observations about how things move. They will need more time to process when things do not match their preconceptions. Don’t hurry them through this process. Deconstructing prior ideas and rebuilding them is an important and time consuming process. If they are going to incorporate new ideas into their views about how the world works, they will need lots of practice with different objects and scenarios. Intentional instruction and specific time set aside for reflection are key for the student. Perhaps keeping the materials out and available for further exploration at a “station” would allow them more time to investigate.

Additional Resources